IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF MASSACHUSETTS

SKYLINE SOFTWARE SYSTEMS, INC., Plaintiff,	)	
v.	)	CIVIL ACTION NO. 04-11129-DPW
KEYHOLE, INC. and GOOGLE INC., Defendants.	)	

DECLARATION OF DINESH MANOCHA, PH.D., IN SUPPORT OF PLAINTIFF'S OPENING CLAIM CONSTRUCTION BRIEF

I, Dinesh Manocha, Ph.D., on oath depose and state that:

1. I know the following information through my own personal knowledge and, if called and sworn as a witness, I could and would competently testify hereto.

2. I make this declaration in support of the claim construction brief filed by Defendants' Keyhole, Inc. and Google Inc. ("Defendants") and provide my opinion as to what the claims of United States Patent No. 6,496,189 ("the '189 Patent") mean to one ordinary skill in the relevant art.

3. My qualifications are stated more fully in my curriculum vitae, a true and correct copy of which is attached as Exhibit I. However, I will provide a brief summary of my relevant qualifications below.

4. For the past two decades, I have focused my academic research in the field of Computer Science. I received my Bachelors degree in Computer Science and Engineering in 1987 from the Indian Institute of Technology in Delhi, India. In 1990, I obtained my Masters of Science in Computer Science from the University of California at

Berkeley, where I specialized in computer graphics and geometric modeling. In 1992, I received my Ph.D. in Computer Science, also from the University of California at Berkeley. My doctoral studies focused primarily on computer graphics, geometric and solid modeling, numeric and symbolic computation and robotics.

5. After obtaining my Ph.D. at University of California at Berkeley, in July 1992, I joined the faculty at the University of North Carolina at Chapel Hill (UNC-CH) in the Department of Computer Science. I am currently the Phi Delta Theta/Mason Distinguished Professor of Computer Science. Over the last 14 years, I have taught courses on Computer Graphics, Robot Motion Planning, General Purpose Computation using Graphics Processors, Geometric and Solid Modeling, Rendering Curved Surfaces, Algorithms and Analysis, Spatial Modeling with Large Datasets, Scientific and Geometric Computation, and Physically-based Simulation. My research at UNC-CH has focused primarily on the design and implementation of algebraic, geometric, and numeric algorithms and their applications to solid modeling, computer graphics, robotics, virtual environments, manufacturing and physically based modeling.

6. I have authored over 200 articles on various aspects of computer science, especially computer graphics. I have also received numerous awards and honors for my work in the field of computer science. I have been working on algorithms and systems to render large datasets stored in local disk memory or remote servers for many years. I have published a number of papers related to hierarchical representations, levels-of-detail or multi-resolution computations, visibility algorithms and streaming large geometric and image datasets over the Internet. My research group at UNC-CH has also developed

many research prototype systems that integrated these representations and algorithmic techniques and tested their performance on different real world large datasets.

7. I have reviewed the '189 Patent and its relevant prosecution history and am familiar with this patent, its claims, and the background technology. I understand that Skyline accuses Defendants of infringing each and every claim of the '189 Patent.

8. I understand that patent claims should be construed from the perspective of a person of ordinary skill in the relevant art at the time the patent application was filed. In my opinion, the relevant art for the '189 Patent is computer graphics. The '189 Patent uses concepts, nomenclature, designs, and systems from the computer graphics art that should be understood in this context. In my opinion, one of the ordinary skill in the art relevant to the subject matter of the '189 Patent at the time the application for the patent was filed would be a person with a bachelor's degree in computer science, mathematics or electrical engineering (or similar field) and possibly a two or more years of experience in the field of software development for client-server applications and data structures. In construing the claims of the '189 Patent, I considered the '189 Patent and its prosecution history from the point of view of one or ordinary skill in the relevant art. I did not read the claim in light of any specific software product accused of infringing or practicing the '189 Patent.

9. I understand that Plaintiff Skyline Software Systems, Inc. ("Skyline") has accused Defendants of infringing each claim of the '189 Patent. I understand that the Court has already construed the disputed claim terms identified by the parties that are contained in Claims 1 and 12 of the '189 Patent. I also understand that, with respect to the remaining claims, the parties have exchanged proposed constructions for claim terms

contained in Claims 2, 3, 7, 8, 9, 11, 13, 14, 18, 19, 21 and 22. After narrowing the list of identified claim terms, I understand that the claim terms contained within the following claims remain in dispute: Claims 2, 3, 7, 8, 9, 11, 13, 14, 16, 18, 19 and 22. I will provide my opinion as to how one of ordinary skill in the art would understand the disputed terms contained in these patent claims.

10. I understand that many of the terms from Claims 1 and 12 whose construction has already been provided by the Court are used elsewhere in other claims. My understanding is that such terms should be construed consistently throughout the patent. Additionally, in my opinion, the disputed terms are used consistently throughout the claims and should therefore be given the same constructions throughout the claims.

11. I further understand that Defendants have identified certain terms that appear in Claims 1 and 12, as well as in additional claims of the '189 Patent, as requiring construction. These terms are: "downloading," "downloading … if the provided block from the local memory is not at the indicated resolution level," "receiving from the renderer," and "providing to the renderer." As the Court has already decided all disputed relating to claim terms appearing in Claims 1 and 12, I do not address those terms below.

MEANING OF DISPUTED CLAIM TERMS IDENTIFIED BY DEFENDANTS

1. *"succession of resolution levels"* (Claim 2)

12. I understand that Defendants have identified the phrase "succession of resolution levels," which appears in Claim 2, as requiring construction by the Court. In my opinion, there is no ambiguity to this phrase with respect to its usage in the field of computer graphics. One of ordinary skill in the art in 1999 would have understood "succession of resolution levels" to refer to the resolution levels of the data as it is stored

in the database in a hierarchical manner. '189 Patent, col. 8, lns. 6-9; col. 9, lns. 1-21. The term refers, in a straightforward manner then, to downloading data from the various resolution levels corresponding to different levels of depth in the hierarchy.

13. Defendants attempt to add more limitations to this claim than found in the straightforward claim language. In particular, Defendants seek to combine a new construction of "downloading" with an overly limited construction of "succession of resolution levels" so that the claim phrase "downloading the blocks from a succession of resolution levels" becomes something much more narrow. The resulting construction appears to be "requesting area network and receiving in local memory from a separate computer data blocks in order of successive resolution levels." The highly constrained term would require that the system request data blocks in order of successive resolution levels and receive those data blocks in local memory in that same order. This is contrary to the teaching in the '189 Patent and to the understanding of one of ordinary skill in the art at the time of the filing of the patent application. The Internet or network protocols used to get this data from the remote server do not guarantee an ordering.

14. When a client computer program makes requests to a server over the Internet, it is common for the client to make several requests (For example, Request A and then Request B) in order. The server's response to those requests may, on occasion, come back to the client in a different order, so that the response to Request B arrives back before the response to Request A. The out-of-order arrival of responses can occur because the server may actually consist of multiple computers or software threads, and Request A is handled by one computer (or thread) while Request B is handled by another computer (or thread) that is less heavily loaded than the computer (or thread) to which

Request A is sent or which, for some other reason, manages to respond to the request more quickly. Out-of-order arrival could also occur because network congestion or routing policy could cause the packet(s) containing Request A to travel a different and slower path from client to server than the path taken by the packet(s) containing Request B. (Information over a network like the Internet is transmitted in the form of units of data called packets, which normally have a bounded size and may be routed through the network independently of each other.) Congestion and/or routing policy can likewise cause the packets(s) containing the response to Request A to travel a different and slower path (*e.g.*, due to network latencies) from server back to client than the path taken by the packet(s) containing the response to Request B. This out-of-order arrival phenomenon, if applied to a stream of requests from the client A-B-C-D-E-F, commonly shows up in the form of a limited random reordering of responses relative to requests, such as for example arrivals in the order A-C-B-E-D-F.

15. A possible analogy to this reordering from daily life is what happens with mail sent via first class mail through the U.S. Postal Service. If I sent a letter on Thursday, and then I sent another letter on Friday to the same address, the general "succession" of the arrival of letters would be that the letter sent on Thursday should arrive before the letter sent on Friday. This is not always the case, depending on the weather, the speed of the mail carriers on the particular day, or the routing used by the U.S. Postal Service, etc. In certain cases, the letter sent on Friday will arrive before the letter sent on Thursday. The same phenomenon occurs when requests are made to a server over the Internet.

16. In interpreting a description of a client-server system that operates over the Internet, I assume unless the description expressly conveys otherwise that responses to requests may arrive out-of-order, since that is the normal situation in such an environment. As such, one of ordinary skill in the art at the time of the invention would not have understood the claim phrase "succession of resolution levels" to require requesting and receiving in precise order.

17. Simply put, the claim term "succession of resolution levels" refers to the manner in which the data blocks are organized in the database, *i.e.*, in a succession of resolution levels. The data blocks that are downloaded then form that hierarchically structured database.

2. *"plurality of coordinates being included in a plurality of respective distinct blocks"* (Claim 3)

18. In my opinion, one of ordinary skill in the art at the time of the invention of claimed in the '189 Patent would understand the term "plurality of coordinates being included in a plurality of respective distinct blocks" to mean "more than one set of coordinates that are used to describe the data contained in more than one data block." This term in Claim 3 simply emphasizes the manner in which the data is organized in data blocks. In the '189 Patent, the user selects a view which the system translates or describes by reference to various coordinates. The data is organized in data blocks of various resolution levels. The data blocks of higher resolution typically describe one quarter of the area of the next resolution level (based on the formulation of the quad tree). Consequently, as stated in Claim 3, higher resolution data blocks requested from the remote server may describe the same area as one lower resolution data block and,

therefore, a number of distinct higher resolution data blocks will correspond to the same plurality of coordinates as the one (or at least fewer) lower resolution data blocks.

19. I understand that Defendants have proposed that this term be construed to mean "each one of the plural sets of coordinates being included in a separate distinct one of a plurality of data blocks describing three-dimensional terrain." Defendants' proposed construction is inconsistent with the plain and ordinary meaning of this phrase and attempts to import limitations not found in or relevant to the claim on the patent.

3. *"when not downloading blocks required by the renderer"* (Claim 7)

20. One of ordinary skill in the art at the time of the invention would have understood the phrase "when not downloading blocks required by the renderer" to mean "when not downloading data for displaying the scene corresponding to the current view." The invention described and claimed in the '189 Patent provides various steps for determining what data blocks to order, determining if one or more of the blocks are in the local memory and if not ordering the blocks from the remote server and providing the requested blocks from the remote server to the client in several asynchronous operations performed in parallel. This asynchronous process of getting the relevant blocks of data from the server can maximize the efficiency of the system, while enabling the system to operate at interactive rates and as an integrated method.

21. In such an asynchronous operation, the multiple threads typically work in parallel with one another. One thread may be downloading requested blocks in the requested resolution level, while another, if not then needed, downloads blocks for the current view, may have started to download blocks around the area of interest (or in its spatial proximity) in order to be ready should the user decide to change focus.

22. I understand that Defendants contend that the claim phrase should be interpreted to mean "during periods of time when the local computer is not downloading data blocks describing three-dimensional terrain in response to the one or more coordinates provided by the renderer." First, because systems may be multithreaded and/or asynchronous, the "periods of time" limitation makes no sense. Second, data blocks are almost always ordered in response to the view requested by the renderer. The claim addresses a method of expanding the blocks available near or surrounding the current view when not downloading blocks required to render the requested view. These blocks are then available for future views and are downloaded as the network may have capacity to download data needed for the current frame and for the future viewpoints.

4. *"Internet"* (Claims 8 and 22)

The claim term "Internet", according to the plain language of the '189 Patent, means "the public world-wide network of that name, which is capable of relaying information via a TCP connection, but not including private networks even if they use internet protocols or have connections to the Internet." Defendants' proposed definition seems to include private networks, albeit implicitly. Defendants contend that the term "Internet" means "a publicly available network capable of relaying information via Internet Protocol, either alone or in connection with one or more other protocols."

Support for Skyline's proposed construction is found throughout the patent specification. To start, Claim 8 provides as follows:

> A method according to claim 7, wherein downloading the data blocks comprised downloading the blocks via the **Internet**.

Exh. B ('189 Patent, col. 17, lns. 62-64) (emphasis added). The specification makes clear that Skyline's invention is intended to operate with simple personal computers,

such as those used in the home and office, over the publicly available Internet. More specifically, the specification of the '189 Patent provides:

> Preferably, the processor connects to the server via a communication link, preferably a *public network, such as the Internet*. Preferably, the data is conveyed by a *standard modem* at sufficient speed for relatively smooth display of the images.

Id., col. __, lns. ___ (emphasis added). The specification further provides:

> FIG. 1 is a schematic illustration of a system 18 for displaying real-life terrain images of a flight course, in accordance with a preferred embodiment of the present invention. System 18 preferably comprises a processor 20, such as a *Pentium-Pro MMX processor*, and a display 22, which are used by an end-user to view 3D real-life images of terrain of desired sites. Preferably, system 18 comprises a modem 24 through which processor 20 communicates with a computerized database server 26 of 3D terrain images. Modem 24 is, for example, *a standard 33,600 kb/sec modem, although other modems, faster and slower may also be employed.* Alternatively, other means of connection, such as ISDN connections or direct routers, may be used instead of modem 24. Preferably, processor 20 communicates with server 26 over a *public network, such as the Internet.* Alternatively or additionally, processor 20 communicates with server 26 through a direct communication line. Further alternatively or additionally, processor 20 receives a storage disk 28, such as a CD, from server 26 or from any other distribution source.

Id., col. __, lns. ___ (emphasis added). Moreover, "Connections 76 are preferably *standard TCP connections* as are known in the art, although any other protocol may be used to form the connection." *Id.*, col. __, lns. ___ (emphasis added); *see also id.*, col. __, lns. __ ("The blocks are preferably realized as software processes running on a general-purpose microcomputer, although dedicated hardware realizations are also possible.").

23. These portions of the specification, as well as the commonly understood meaning of the term at the time of the invention, clearly define the term "Internet" as: (1) a publicly accessible network; (2) capable of relaying information via a TCP connection.

That public network may be accessed by private networks, but such a private network is not the Internet.

24. Put another way, the Internet is the network over which home computers normally communicate with business computers (eBay's, for example), and is also a common means for computers in one business to communicate with computers in another business. To communicate "via the Internet," as recited in Claim 1, means that the communication goes over that one Internet. Packets (the units of network communication) pass through that one Internet. Communicating "via the Internet" does not mean simply that the communication goes, as Google contends, over any network which is in some sense publicly accessible, and which uses the Internet protocol. That is like saying that if you go from Harvard Square to Back Bay by driving on Massachusetts Avenue and over the Harvard Bridge, you are driving via the Mass Pike. Massachusetts Avenue is certainly connected to the Mass Pike (analogous to being on a network from which the Internet is accessible), and one drives on Massachusetts Avenue in much the same way that one drives on the Mass Pike (analogous to using the Internet protocols on a private network), but unless a particular trip involves the car actually getting on the Mass Pike, one is still not driving via the Mass Pike.

5. *"substantially all of the blocks surrounding a point in the terrain seen from the current viewpoint within a predetermined distance range"* (Claims 9 and 19)

25. The claim phrase "substantially all of the blocks surrounding a point in the terrain seen from the current viewpoint within a predetermined distance range" should be construed as "substantially all of the blocks which include data covering terrain which is within a predetermined distance range in one or more directions from either the

viewpoint or a point in the terrain visible from the current viewpoint." Claim 9 provides as follows:

> A method according to claim 7, wherein the renderer renders a view from a current viewpoint, and wherein downloading the excess blocks comprises filling the local memory with substantially all of the blocks surrounding a point in the terrain seen from the current viewpoint within a predetermined distance range.

'189 Patent, col. __, lns. __.

26. Defendants propose the following construction: "substantially all of the excess blocks describing three-dimensional terrain on all sides out to a pre-established distance boundary around a point in the terrain that is seen from the current viewpoint." This proposed construction unnecessarily requires all sides or direction in three dimensions, whereas Skyline's definition merely requires "one or more directions." In Skyline's invention, the data organized in a hierarchical structure generally represents the surface of the Earth, but not the volume of the Earth. The satellite and/or aerial data basically describe the surface of the Earth, with three dimensional data for that surface. This is referred to as a two dimensional representations or a manifold. In that light, the claim refers to expanding the data for a view laterally along the surface in all directions. There may be no terrain data for the interior of the Earth and the data structures described in the patent (*e.g.*, '189 Patent, col. 9, lns. 15-21; Fig. 2) do not describe such a three dimensional collection of data blocks (*e.g.*, an octree-based representation).

27. In this context, Defendants' proposed requirement of all sides imposes a restriction that is not supported by the claim language or by the plain and ordinary understanding of this phrase.

I declare under penalty of perjury under the laws of the United States this 29th day of September 2006 that, to the best of my knowledge, the foregoing is true and correct.

Dinesh Manocha, Ph.D.

EXHIBIT A

Dinesh Manocha

Phi Delta Theta/Matthew Mason Distinguished Professor

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CONTENTS

EDUCATION

University of California at Berkeley

Ph.D. in Computer Science, May 1992

Thesis title: Algebraic and Numeric Techniques for Modeling and Robotics
Thesis supervisor: John F. Canny
Major: Geometric and Solid Modeling, Computer Graphics, Numeric and Symbolic Computation, Robotics
Minors: Mathematics and Software Systems

M.S. in Computer Science, 1990

Specialization in Computer Graphics and Geometric Modeling

Indian Institute of Technology, Delhi, India

B.E. in Computer Science and Engineering, 1987

APPOINTMENTS

- Phi Delta Theta/Matthew Mason Distinguished Professor, Department of Computer Science, Professor, University of North Carolina at Chapel Hill, July, 2006 –present.
- Professor, Department of Computer Science, University of North Carolina at Chapel Hill, January 2001-June 2006.
- Associate Professor, Department of Computer Science, University of North Carolina at Chapel Hill, January 1998-December 2000.
- Visiting Researcher, Microcomputer Research Lab (MRL) at Intel, Santa Clara, CA, May 1998-August 1998; May 1999-August 1999.
- Assistant Professor, Department of Computer Science, University of North Carolina at Chapel Hill, July 1992-December 1997.
- Post Doctorate Researcher, Department of Electrical Engineering and Computer Science, University of California at Berkeley, May 1992-August 1992.
- Research & Teaching Assistant, Department of Electrical Engineering and Computer Science, University of California at Berkeley, August 1988-May 1992.
- Research Visitor, General Motors Research Laboratory, May 1989-August 1989.
- Research Visitor, Olivetti Research Center, May 1988-August 1988.
- Research & Teaching Assistant, Department of Computer Science, Purdue University, November 1987-May 1988.

HONORS AND AWARDS

1. 2006: Awarded Phi Delta Theta/Matthew Mason Distinguished Professor
2. 2005: Best Paper, Research and Development Track, I/ITSEC, 2005
3. 2005: Best Paper Award, IEEE VR 2005.
4. 2004: Best Paper Award, Pacific Graphics 2004.
5. 2003: Best Paper Award, ACM/SIGGRAPH Conference on Solid Modeling and Applications.
6. 2001: Best Paper Award, ACM Multimedia Conference.
7. 2001: Best Panel Award, IEEE Visualization Conference.
8. 1999: Best Paper Award, Eurographics Conference.
9. 1998: Hettleman Award for Scholarly Achievement, UNC Chapel Hill.
10. 1998: Honda Research Award.
11. 1997: Office of Naval Research Young Investigator Award.
12. 1996: Best Paper Award, SuperComputing, 2006

13. 1995: National Science Foundation CAREER Award.
14. 1995: Presidential Faculty Fellow nominee, The University of North Carolina at Chapel Hill.
15. 1995: Alfred P. Sloan Fellow.
16. 1993: Research Award from University Research Council, University of North Carolina at Chapel Hill.
17. 1992: Junior Faculty Award at the University of North Carolina at Chapel Hill.
18. 1992: Research award by Mitsubishi Electric Research Laboratory for research on inverse kinematics and its application to robotics and graphics.
19. 1991: IBM Graduate Fellowship.
20. 1988: Alfred and Chella D. Moore Fellowship for graduate studies in Computer Science at the University of California at Berkeley.
21. 1983-87: Merit Prizes and Certificates for Academic Excellence at the Indian Institute of Technology, Delhi, India.
22. 1983: Merit Prize and Certificate for obtaining VII position in All India Senior Secondary Certificate Examination.
23. 1981-87: National Talent Scholarship by the Government of India.
24. 1979-81: Junior Science Talent Scholarship by the Government of India.

PROGRAM & WORKSHOP CHAIR POSITIONS

1. Program Co-Chair, ACM Solid and Physical Modeling, 2007
2. Workshop Co-Chair, EDGE Computing Workshop, 2006
3. Program Co-Chair, Pacific Graphics, 2005.
4. Workshop Co-Chair, ACM Workshop on General Purpose Computation using Graphics Processors, ACM SIGGRAPH, 2004.
5. Workshop Co-Chair, WIHAVE, Workshop on Intelligence, Human Augmentation and Virtual Environments, 2002.
6. Video Program Committee Chair: ACM Symposium on Computational Geometry, 2001.
7. Program Chair: ACM Workshop on Applied Computational Geometry, Philadelphia, PA, 1996.
8. Program Co-Chair: Workshop on Simulation, Behavior, and Action in Virtual Environments, Iowa (sponsored by ONR and ACM SIGGRAPH), 1995.

EDITORIAL DUTIES

1. Editorial Board Member, Journal of Applicable Algebra (AAECC), 2003-Present
2. Associate Editor, Graphical Models and Image Processing, 1999-Present
3. Associate Editor, IEEE Transactions on Visualization and Computer Graphics, 1999-2003
4. Guest Co-Editor, International Journal on Computational Geometry and Applications, two special issues on Applied Computational Geometry, 1998.
5. Guest Co-Editor, IEEE Computer Graphics and Applications, special issue on handling large datasets, 2007

CONTRACTS AND GRANTS

Current Support

1. 2006-2009: "Multiresolution Algorithms for Processing Giga-Models: Real-time Visualization, Reasoning, and Interaction", Army Research Office, Co-PI, $335K.
2. 2006: "Support for EDGE Workshop", DARPA, DTO, NSF, NVIDIA and ATI, PI, $65K.

3. 2005-2008: "Computer Generated Force Scalability", Army RDECOM, PI (about $2.5M).
4. 2005-2007: "Exploiting Cyber-Infrastructure for Creation and Use of Multi-Disciplinary Engineering Models", NSF, Co-PI, $250K.
5. 2006-2007: "High Performance Clusters for Modeling and Simulation", Army Research Office, DURIP program, PI, $82K.
6. 2004-2007: "Multiresolution Algorithms for Virtual Prototyping of Massive CAD Models", NSF, PI (about $384K).
7. 2002-2006: "Handling Complex Datasets: Representation, Interactive Display and Interaction", Army Research Office, PI (about $395K).
8. 2003-2006: "Enabling Real-Time Interaction for Moving Avatars in Virtual Environments", Office of Naval Research, Co-PI (about $560,000).
9. 2001-2006: "High Fidelity Virtual Touch: Algorithms, Applications and Evaluation", National Science Foundation, Co-PI (about $370K).

Pending Support

Past Support

1. 2004-2006: "Portable Walkthrough and Computer Generated Force Computation", DOD, PI (about $80K).
2. 2005-2007: "Missile Plume Simulation Improvements using GPU Chemical Kinetics Coprocessor", $50K, PI, MDA.
3. 2001-2005: "Real time Physically-Based Modeling and Interaction", Intel, Co-PI ($225K, direct costs + $75K equipment).
4. 2005-2006: "Efficient layouts of large datasets", DOE LLNL, PI (about $30K)
5. 2004-2006: "Interactive OneSAF Computations using COTS Graphics Hardware", DARPA, PI (about $875K).
6. 2000-2005: "Real Time Interaction in Virtual Environments", Office of Naval Research, Co-PI (about $645K).
7. 1999-2005: "Research in Walkthroughs and Simulation", Alias/Wavefront, Principal Investigator ($495K software donation).
8. 1999-2004: "Real-Time Walkthroughs of Serious Synthetic Environments", National Science Foundation, Principal PI (about $480,000).
9. 2004: "Support for ACM Workshop on General Purpose Computation using Graphics Processors", NVIDIA, ATI, 3D Labs, RDECOM, PEO-STRI & Army Research office.
   Co-PI, (about $35K).
10. 1999-2002: "Accurate Boundary Evaluation and Interactive Display of Large Solid Models", Army Research Office, PI (about $250,000).
11. 1999-2003: "Interactive Display of Complex Datasets", Lawrence Livemore National Labs (DOE ASCI Program), PI (about $1,250,000).
12. 2001-2003: "Instrumentation for Interactive Display of Complex Datasets", Army Research Office, PI (about $173K).
13. 2000-2003: "Video Based Representations and Rendering of Large Real and Synthetic Environments", Office of Naval Research, PI (about $315K).
14. 1998-2001: "Acquisition of a Graphics Supercomputer for Synthetic Environments Serving Science and Engineering", National Science Foundation, Co-Pr (about $1,460,000).
15. 1997-2000: "Interactive Walkthrough of large CAD models", Office of Naval Research, PI (about $375,000).
16. 1999-2000: "Support for Research in Collision Detection and Interactive Walkthroughs", Intel, PI (about $130,000).

17. 1999-2000: "Web based Distance Education Curricula for Computer Graphics and Scientific Computing", UNC Chapel Hill, PI (about $12,000).
18. 1998-2000: "Instrumentation for Interactive Synthetic Environments", Department of Defense DURIP Award, PI (about $232,000).
19. 1997-99: "Interactive Computer Graphics", Intel Research Award, PI (about $290,000).
20. 1997-98: "Virtual Reality Station", Office of Naval Research, PI (about $160,000).
21. 1997-2000: "Technology for Education 2000 Program", Intel, Co-PI (about $2,870,000).
22. 1996-2000: "CAREER: Algebraic and Geometric Techniques for Interference Detection in Static and Dynamic Environments", National Science Foundation, PI (about $200,000).
23. 1996-97: "Interactive Modeling and Interactive Visualization of Complex Datasets", DOD DURIP Proposal, PI (about $137,000).
24. 1996-99: "Modeling and interactive walkthrough of large CAD models", Army Research Office, PI (about $246,000).
25. 1995-97: "Sloan Fellowship", (about $30,000).
26. 1996-98: "Interactive Collision Detection for Virtual Environments", Ford Motor Company, PI (about $22,500).
27. 1994-98: "Numeric and Symbolic Manipulation of Polynomial Systems", National Science Foundation, PI (about $200,000).
28. 1996-97: "Supplemental Support for Interactive Model Construction, Display and Collision Detection for Virtual Environments", Office of Naval Research, PI (about $25,000).
29. 1995-96: "Simulation-Based Design", DARPA Sub-Contract, Monitored by Lockheed Martin, Co-PI (about $400,000).
30. 1996: "Travel support for ACM Workshop on Applied Computational Geometry", National Science Foundation, PI (about $8,000).
31. 1995-96: "Model construction and interactive walkthrough of large CAD models", Army Research Office, PI (about $125,000).
32. 1994-97: "Interactive Model Construction, Display and Collision Detection for Virtual Environments", Office of Naval Research, PI (about $250,000).
33. 1994: "Modeling with Non-Linear Constraints", University Research Council, UNC Chapel Hill, PI (about $2000).
34. 1994-95: "Workshop on simulation and interaction in virtual environments", Office of Naval Research, Co-PI (about $10,000).
35. 1993-96: "Enabling Technologies and Application Demonstrations for Synthetic Environments", Advanced Research Projects Agency, Senior Investigator. Fred Brooks and Henry Fuchs, Principal Investigators (about $3,300,000).
36. 1993: Junior Faculty Award, UNC Chapel Hill, Principal Investigator (about $3000).

PROGRAM COMMITTEES

1. ACM Solid and Physical Modeling, 2003-2006.
2. 3D Data Processing, Visualization and Transmission 2006
3. ACM SIGGRAPH/Eurographics Workshop on Computer Animation, 2003-2006.
4. ACM SIGGRAPH/Eurographics Workshop on Graphics Hardware, 2004-2006.
5. Computer Animation and Social Agents, 2003-2006.
6. ACM/Eurographics Symposium on Geometry Processing, 2003-2006.
7. Computer Graphics International, 1998-2005.
8. Eurographics, 2002-2004.
9. Pacific Graphics, 2004-06.
10. International Symposium on 3D Data Processing, Visualization and Transmission, 2004..
11. X Mathematics of Surfaces Conference, England, 2003.

12. IEEE Visualization, 2001-2002.
13. IEEE VR Conference, 2000-2002.
14. Computer Animation, 2001-2002.
15. Senior Reviewer, ACM SIGGRAPH, 2000.
16. Indian Conference on Computer Vision, Graphics and Image Processing, 2000.
17. Workshop on Algorithmic Foundations of Robotics, 2000.
18. ACM Symposium on Solid Modeling, Ann Arbor, MI, 1997-2001.
19. International Association of Science and Technology for Development (IASTED), Computer Graphics and Imaging, Canada, 1999.
20. IEEE VRAIS'98 Conference, Atlanta, GA, 1998.
21. 3rd ASME Design for Manufacturing Conference, Atlanta, GA 1998.
22. ACM Symposium on Computational Geometry, Minneapolis, MN, 1998.
23. International Association of Science and Technology for Development (IASTED), Computer Graphics and Imaging, Canada, 1998.
24. Constructive Solid Geometry'98, Winchester, England, 1998.
25. IEEE VRAIS'97 Conference, Albuquerque, NM, 1997.
26. ACM Symposium on Computational Geometry, Nice, France, 1997.
27. Workshop on Collaborative CAD, Atlanta, GA, 1997.
28. VRST'96 Conference, Hong Kong, 1996.
29. IEEE VRAIS'96 Conference, San Francisco, 1996.
30. Constructive Solid Geometry (CSG)'96 Conference, Winchester, England, 1996.
31. 2nd IEEE Computer Society Workshop on Shape and Pattern Matching in Computational Biology, Boston, MA, 1995.

PANELS

- NSF Panels on New Technologies, Visualization, Geometric Computing, CPA, Compilers, Graphics, Engineering Design.
- NSF CISE Infrastructure Awards.

INVITED TALKS AND DISTINGUISHED LECTURES

1. Invited Panel Speaker, NSF DMII PI Meeting, July, 2006.
2. Keynote Speaker, Pacific Graphics, October 2005
3. First International Workshop on Data Management on New Hardware, Baltimore, MD, June 2005
4. Motion Planning Workshop, Toulouse, France, January 2005.
5. Workshop on Modeling & Simulation: The Next Decade, Las Cruces, NM, December 2004.
6. Inter-service/Industry, Training Simulation Conference (I/ITSEC), Orlando, FL, December 2004.
7. Dist. Lecture Series Speaker, Arizona State University, November 2004.
8. Keynote Speaker, Graphics Interface Conference, London, Ontario, May 2004.
9. DIMACS Workshop on Computer-Aided Design and Manufacturing, Rutgers, NJ, October 2003.
10. Dagstuhl workshop on hierarchical methods, Germany, June 2003.
11. Workshop on Geometric Modeling and Animation, FoCM, Minneapolis, August 2002.
12. Mini-Symposium on Computational Geometry, Curves and Surfaces Conference, St. Malo, June 2002.
13. Mini-Symposium on Robustness, SIAM Conference on Geometric Design, Sacramento, CA, 2001.
14. Workshop on Uncertainty in Geometric Computation, The University of Sheffield, July 2001.
15. Workshop on Surgical Simulation, Stanford, CA, June 2001.
16. NRL Workshop on Augmented Reality, Washington, DC, December 2000.

17. AMS Symbolic Computation: Solving Equations in Algebra, Geometry, and Engineering, Mount Holyoke College, MA, 2000.
18. Workshop on Key Research Issues and Opportunities in Motion Planning, LAAS Toulouse, France, 2000.
19. Workshop on Image Synthesis and Interactive 3D Graphics, Dagstuhl, Germany, 2000.
20. Workshop on Motion Support in Virtual Prototyping, Stanford, CA, May 1999.
21. Mini-Symposium on Applications of Computer Algebra in Industry, SIAM Annual Meeting, Atlanta, GA, 1999.
22. NSF/DOE Workshop on Large Scale Visualization and Data Management, Salt Lake City, Utah, May 1999.
23. Eighth IMA Conference on Mathematics of Surfaces, University of Birmingham, England, 1998.
24. Workshop on Hierarchical Methods in Computer Graphics, Dagsthul, Germany, 1998.
25. ACM Siggraph Course on Interactive Walkthroughs, Los Angeles, CA, 1997.
26. Geometry Software Workshop, Nice, France, June 1997.
27. ACM Symposium on Computational Geometry, Nice, France, 1997.
28. American Mathematical Society Course on Computational Algebraic Geometry, San Diego, CA, 1997.
29. 1st CGC Workshop on Computational Geometry, Johns Hopkins University, Baltimore, MD, October 1996.
30. 2nd Workshop on Algorithmic Foundations of Robotics, Toulouse, France, July 1996.
31. Graphicon'96: The 6th International Conference & Exhibition on Computer Graphics and Visualization, St. Petersburg, Russia, July 1996.
32. Workshop on Software & Mathematical Visualization, Princeton, NJ, June 1996.
33. East Coast Computer Algebra Day, IBM TJ Watson Research Center, April 1996.
34. Workshop on Algebra for Solving Real Polynomials, Park City, UT, July 1995.
35. Geometry Software Workshop, Geometry Center, University of Minnesota, January 1995.
36. SPIE Conference on Curves and Surfaces for Computer Graphics, Boston, MA, 1992.
37. Invited Mini-Symposium Speaker, SIAM Conference on Geometric Design, Tempe, AZ, 1991, 1993.

COURSES AND TUTORIALS

1. *State of the Art in Interactive Ray Tracing* (with P. Shirley, I. Wald, W. Mark and P. Slusallek) ACM SIGGRAPH 2006.
2. *Realtime Interactive Massive Model Visualization* (with D. Kasik, I. Wald, B. Bruderlin, W. Correa, E. Gobbetti, Al. Hubrecht and P. Slusallek) Eurographics 2006.
3. *Query Co-processing on Commodity Hardware,* Co-organizer (with N. Govindaraju and Anastassia Ailamaki), International Conference on Data Engineering, 2006.
4. *Collision handling in dynamic simulation Environments,* Co-organizer (with M. Trescher), Eurographics, *2005.*
5. *Interactive Geometric and Scientific Computations using Graphics Hardware,* Course Organizer, SIGGRAPH, 2003.
6. *Interactive Geometric Computations with Graphics Hardware*, Course Organizer, ACM SIGGRAPH, 2002.
7. *Handling Large Datasets: Interactive Walkthroughs and Proximity Queries*, Co-Organizer with Ming C. Lin, ACM Solid Modeling, 2002.
8. *Interactive Walkthroughs of Large Geometric Datasets*, Course Organizer, ACM Solid Modeling, 2001.
9. *Interactive Walkthroughs of Large Geometric Environments*, Co-Organizer with Daniel Aliaga, ACM SIGGRAPH, 2000.
10. *Interactive Walkthroughs of Large Geometric Datasets*, Course Organizer, ACM SIGGRAPH, 1999.

SELECTED PRESS COVERAGE

1. *Slashdot News, May 2006*
2. *DARPA Legacy Press Release,* August 2005
3. *Tom's Hardware Guide,* June 2005
4. *Slashdot News,* June 2005
5. *Interactive Shadow Generation,* Millimeter Magazine, June 2003.
6. *Shadow Generation,* ExtremeTech Magazine, April 2003.
7. *Virtual Dreams,* Silicon India, 2002.
8. *Painting with Feeling,* Computer Graphics World, 2001.
9. *Feeling the Brush,* Endeavor, 2001.
10. *Walkthrough of Big Structures,* Technology Research News, 2001.
11. *Painting Software's Brush with Realism,* NewScientist.com, 2001.
12. *Walkthru Project Renders Real-Time 3D Models for Engineering and Architecture,* NSF Press Release, 2001.
13. *Fast Collision Detection,* Gamasutra, 1999, 2000.

DEPARTMENT COMMITTEES

- Faculty Search Committee
- Graduate Admissions
- Publications Committee
- Department Colloquium Organizer
- Library Committee
- Department Chair polling committee
- Adhoc Committee on role of Research Faculty (chair)
- Exam Committee (chair)

UNIVERSITY COMMITTEES

- Graduate School Administrative Board
- Graduate School Fellowship Committee
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COURSES TAUGHT

- COMP122: Design and Analysis of Algorithms
- COMP205: Scientific and Geometric Computation
- COMP236: Computer Graphics
- COMP258: Geometric and Solid Modeling
- COMP259: Physically-based Modeling
- COMP290: Advances in Modeling
- COMP290: Rendering Curved Surfaces
- COMP290: Robot Motion Planning
- COMP290: General Purpose Computation using Graphics Processors

SOFTWARE SYSTEMS

1. I-COLLIDE (1995) Collision Detection System: A polyhedral collision detection system developed by J. Cohen, M. Lin, D. Manocha, B. Mirtich, K. Ponamgi and J. Canny. More than 4500+ users have ftp'ed the code. The underlying technology has been licensed to Mechanical Design Inc., Division Inc., and Knowledge Revolution. Also used by researchers at Ford Motor Company, Intel, GE, White Sands Missile Range, Lockheed Martin, etc.
2. Polygon Triangulation Utility (1995) Developed by A. Narkhede and D. Manocha. More than 2200+ users worldwide have ftp'ed the code.
3. SPEED Rendering System (1996) A rendering system for interactive display of large NURBS models, developed by S. Kumar and D. Manocha
4. RAPID (1996) Interference Detection System: A general purpose polygonal interference detection system developed by S. Gottschalk, M. Lin and D. Manocha. More than 7,000 users have ftp'ed the code (as of July 2006). The underlying technology has been licensed to Division Inc. Also used by researchers at ABB Engineering, Intel, Ford, White Sands Missile Range, etc.
5. V-COLLIDE (1997) Collision Detection System: A general purpose collision detection system for general large environments developed by J. Cohen, S. Gottschalk, T. Hudson, A. Pattekar, M. Lin and D. Manocha. More than 5000 downloads (as of July 2006).
6. BOOLE (1997) Solid Modeling System: An accurate solid modeling system for spline models developed by S. Krishnan, D. Manocha, A. Narkhede and J. Keyser. The system was being integrated with BRL-CAD, a public domain solid modeling system with more than 900 users worldwide. Also used by researchers at Air Force Labs.
7. KINEM (1998) Inverse Kinematics Utility: An inverse kinematics utility for general serial manipulators. The system has been used by researchers at Pratt & Whitney, Silma Inc. and Adelph Technologies..
8. MARS (1998) Equation Solver: A zero dimensional equation solver using Matlab and Maple. Developed by A. Wallack, I. Emiris and D. Manocha.
9. MAPC (1999) Library: A package to represent and manipulate algebraic points and curves. Developed by J. Keyser, T. Culver, D. Manocha and S. Krishnan.
10. PQP (1999) Proximity Query System: A general purpose proximity query system for collision detection, distance computation and tolerance queries. Developed by E. Larsen, S. Gottschalk, M. Lin and D. Manocha. 3800+ downloads (as of July 2006).
11. PIVOT (2001) Proximity queries using graphics hardware. It provides support for different proximity queries. Developed by K. Hoff, A. Zaferakis, M. Lin and D. Manocha. 700+ downloads (as of July 2006).
12. DEEP (2002) A package for collisions and penetration computation between convex primitives. Developed by Y. Kim, M. Lin and D. Manocha. 350+ downloads as of July'06.
13. HAVOC (2003): A GPU-based library to compute distance fields of 3D objects and proximity query applications. 100+ download till July'06.
14. GPUSORT (2005): A GPU-based Sorting algorithm and library. More than 1100 downloads until July'06.
15. OpenCCL (2005): A library to compute cache-oblivous layouts of larges meshes and graphs. More than 250+ download till July'06
16. LUGPULIB (2005): A library to compute LU decomposition of dense matrices using graphics hardware. 400+ downloads till July'06.
17. GPUFFTW (2006): A library to compute 1D FFT using GPUs. 900+ downloads till July'06

PUBLICATIONS

Published more than 200 refereed papers in leading conferences and journals in Computer Graphics, Robotics, CAD/CAM, Virtual Reality, Symbolic Computation, Computational Biology and Computational Geometry.

Books and Monographs

1. *Applied Computational Geometry: Towards Geometric Engineering*, edited by Ming C. Lin and Dinesh Manocha, Springer-Verlag, 1996.

2. *Applications of Computational Algebraic Geometry*, by David Cox, Bernd Sturmfels, Dinesh Manocha, Thomas Sederberg, Xenia Kramer, Rienhard C. Laubenbaches, Rekha Thomas and John Little, American Mathematical Society, 1997.

3. *Proceedings of Pacific Graphics,* edited by Dinesh Manocha, Craig Gotsman and Enhua Wu. Published as special issue of Visual Computer. 2005.

Refereed Journal and SIGGRAPH Publications

4. Y. Kim, S. Redon, M. Lin and D. Manocha, "Interactive continuous collision detection using swept volume of avatars", *Presence*, 24 pagers, 2007 (to appear).

5. G. Varadhan and D. Manocha, "Star-shaped Roadmaps – A deterministic sampling approach for complete motion planning", *International Journal of Robotics Research,* 2007 (to appear).

6. A. Sud, N. Govindaraju, R. Gayle, I. Kabul and D. Manocha, "Fast proximity computation among deformable models using discrete Voronoi diagrams", *ACM Trans. On Graphics (Proc. of ACM SIGGRAPH),* 2006 (to appear).

7. S. Yoon, C. Lauterbach and D. Manocha, "R-LODs: Fast LOD-based Ray Tracing of Massive Models", *Visual Computer (Proc. Of Pacific Graphics), 2006* (to appear).

8. S. Yoon and D. Manocha, "Cache-efficient layouts of bounding volume hierarchies", *Computer Graphics Forum* (Proc. of Eurographics), 2006.

9. A. Sud, M. Foskey and D. Manocha (2006). "Homotopy-preserving medial axis simplification." *International Journal on Computational Geometry, 2006.* Special issue on papers from ACM Solid and Physical Modeling.

10. I. Emiris, E. Fritzilas and D. Manocha, "Algebraic algorithms for structure determination in biological chemistry", *International Journal of Quantum Chemistry*, 24 pages, 2006.

11. S. Yoon, P. Lindstrom, V. Pascussi and D. Manocha (2005). "Cache-oblivious mesh layouts." *ACM Trans. On Computer Graphics (Proc. Of ACM SIGGRAPH),* 8 pages, 2005.

12. N. Govindaraju, D. Knott, N. Jain, I. Kabul, R. Tamstorf, R. Gayle, M. Lin and D. Manocha (2005). "Interactive collision detection between deformable models using chromatic decomposition." *S, ACM Trans. On Computer Graphics (Proc. Of ACM SIGGRAPH)*, 9 pages, 2005.

13. D. Manocha, "General Purpose Computation using Graphics Processors", *IEEE Computer*, August, 2005, 4 pages.

14. M. Verdesca, J. Munro, M. Hoffman, M. Bauer, and D. Manocha, "Using graphics processing units to accelerate OneSAF: A case study in technology transition", *Jounnal of Defense Modeling and Simulation* (speial issue on selected papers from I/ITSEC'05), 2005.

15. N. Govindaraju, M. C. Lin and D. Manocha (2005), "Efficient collision culling among deformable objects using graphics processors", *Presence*, 2005. Special issue on papers from IEEE VR.

16. N. Jain, I. Kabul, N. Govindaraju, M. Lin and D. Manocha (2005). "Multi-resolution collision handling among cloth-like Objects", *Computer Animation and Virtual Worlds, 2005.* Special issue on papers from *CASA 2005.* (to appear).

17. S. Yoon, B. Salomon, R. Gayle and D. Manocha, "Quick-VDR: interactive view-dependent rendering of massive models", *IEEE Trans. On Visualization and Computer Graphics*, 14 pages, 2005. Special issue of papers from IEEE Visualization'04.

18. G. Varadhan and D. Manocha. "Accurate Minkowski sum approximation of polyhedral models." *Graphical Models*, 2005. Special issue of papers from Pacific Graphics'04.

19. N. Govindaraju, M. Lin and D. Manocha. "Fast and reliable collision culling using GPUs." *IEEE Trans. On Visualization and Computer Graphics*, 2005. Special issue on papers from VRST'04.

20. S. Redon. Y. Kim, M. C. Lin and D. Manocha. "Fast continuous collision detection for articulated models", *Computer-Aided Design*, 14 pages, 2005. Special issue on papers from ACM Solid Modeling'04.

21. G. Varadhan, S. Krishnan, TVN Sriram and D.Manocha. "A simple algorithm for complete motion planning of translating polyhedral robots." *International Journal of Robotics Research*, 16 pages, 2005. Special issue of papers from WAFR'04.

22. Sud, M. Otaduy and D. Manocha. (2004). "DiFi: Fast 3D distance field computation using graphics hardware." *Computer Graphics Forum (Proc. of Eurographics).*

23. Y. Kim, M. Lin and D. Manocha (2004). "Fast penetration depth computation between convex polytopes." *IEEE Transactions on Visualization and Computer Graphics*, 12 pages.

24. M. Foskey, M. Lin and D. Manocha (2004). "Efficient computation of a simplified medial axis." Special issue of *ASME Journal of Computing and Information Science in Engineering.*

25. Y. Kim, G. Varadhan and M. Lin and D. Manocha (2004). "Fast swept volume approximation of complex polyhedral models." Special issue of *Computer-Aided Design.*

26. T. Culver, J. Keyser and D. Manocha (2004). "Accurate computation of medial axis of a polyhedron." *Computer Aided Geometric Design*, 33 pages.

27. T. Culver, J. Keyser, S. Krishnan and D. Manocha (2003). "A hybrid approach for determinant signs of moderate-sized matrices." *International Journal of Computational Geometry and Applications*, 27 pages.

28. A. Wilson and D. Manocha (2003). "Simplifying complex environments using incremental textured depth meshes." *ACM Trans. On Computer Graphics (Proc. Of ACM SIGGRAPH)*, 10 pages.

29. N. Govindraju, B. Llyod, S. Yoon, A. Sud and D. Manocha (2003). "Interactive shadow generation in complex environments." *ACM Trans. On Computer Graphics (Proc. Of ACM SIGGRAPH)*, 10 pages.

30. J. Keyser, T. Culver, M. Foskey, S. Krishnan, and D. Manocha, (2003). "ESOLID- A system for exact boundary evaluation." *Computer-Aided Design, Special issue on ACM Solid Modeling* 2003, vol. 36(2), pp. 175-193.

31. Y. Kim, K. Hoff, M. Lin and D. Manocha (2003). "Closest point query among the union of convex polytopes using rasterization hardware." *Journal of Graphics Tools, Special issue on Graphics Hardware*, pp. 43-52, vol. 7(4).

32. J. Cohen, D. Manocha, and M. Olano (February 2003). "Successive mappings: An approach to polygonal mesh simplification with guaranteed error bounds." *International Journal of Computational Geometry & Applications*, vol. 13(1). pp. 61-94.

33. Y. Kim, M. Otaduy, M. Lin and D. Manocha (2003). "Six-Degree-of-Freedom haptic display using incremental and localized computations." *Presence*, 33 pages.

34. P. Agarwal, L. Guibas, H. Edelsbrunner, J. Erickson, M. Isard, S. Har-Peled, J. Hershberger, C. Jensen, L. Kavraki, M. Lin, D. Manocha, D. Metaxas, B. Mirtich and D. Mount (2002). "Algorithmic issues in modeling motion." *ACM Computing Surveys*, vol. 24, no. 4, pp. 550-572.

35. S. Krishnan, D. Manocha, M. Gopi, T. Culver and J. Keyser (2001). "BOOLE: A boundary evaluation system for boolean combinations of sculptured solids." *International Journal on Computational Geometry and Applications*, vol. 11, no. 1, pp. 105-144.

36. B. Baxter, V. Scheib, M. Lin and D. Manocha (2001). "DAB: Interactive haptic painting with 3D virtual brushes." *Proc. of ACM SIGGRAPH*, pp. 461-468.

37. J. Keyser, T. Culver, D. Manocha and S. Krishnan (2000). "Efficient and exact manipulation of algebraic points and curves." *Computer-Aided Design*, vol. 32, no. 11, pp. 649-662. Special issue on Robustness.

38. S. Krishnan and D. Manocha (2000). "Hidden surface removal algorithms for sculptured models." *Graphical Models and Image Processing*, vol. 62, no. 4, pp. 283-307.

39. A. Gregory, A. State, M. C. Lin, D. Manocha and M. Livingston (1999). "Interactive surface decomposition for polyhedral morphing." *Visual Computer*, vol. 15, pp. 453-470.

40. M. Gopi and D. Manocha (1999). "Simplifying spline models." *Computational Geometry: Theory and Applications*, vol. 14, pp. 67-90.

41. K. Hoff, T. Culver, J. Keyser, M. Lin and D. Manocha (1999). "Fast computation of generalized voronoi diagrams using graphics hardware," *Proceedings of ACM SIGGRAPH.*

42. J. Keyser, S. Krishnan and D. Manocha (1999). "Efficient and accurate B-rep generation of low degree sculptured solids using exact arithmetic: I – representations." *Computer-Aided Geometric Design*, vol. 16, no. 9, pp. 841-859.

43. J. Keyser, S. Krishnan and D. Manocha (1999). "Efficient and accurate B-rep generation of low degree sculptured solids using exact arithmetic: II – computation." *Computer-Aided Geometric Design*, vol. 16, no. 9, pp. 861-882.

44. A. Wilson, E. Larsen, D. Manocha and M. Lin (1999). "Partitioning and handling massive models for interactive collision detection", *Computer Graphics Forum*, vol. 18, no. 3, pp. 319-329. Received Best Paper Award at Eurographics 1999.

45. S. Kumar, D. Manocha, W. Garrett and M. Lin (1999). "Hierarchical backface computation." *Computer and Graphics*, vol. 9, no. 5, pp. 681-692. Special Issue on Visibility, 1999.

46. A. Wallack and D. Manocha (1998). "Robust Algorithms for Object Localization." *International Journal on Computer Vision*, vol. 27, no. 3, pp. 243-262.

47. S. Krishnan, M. Gopi, M. Lin, D. Manocha and A. Pattekar (1998). "Rapid and accurate contact determination between spline models using ShellTrees." *Computer Graphics Forum.*

48. J. Cohen, M. Olano and D. Manocha (1998). "Appearance preserving simplification." *Proceedings of ACM SIGGRAPH*, pp. 115-122.

49. H. Zhang, D. Manocha, T. Hudson and K. Hoff (1997). "Visibility culling using hierarchical occlusion maps." *Proceedings of ACM SIGGRAPH.*

50. S. Krishnan and D. Manocha (1997). "An efficient surface intersection algorithm based on the lower dimensional formulation." *ACM Trans. on Graphics*, vol. 16, no. 1, pp. 74-106.

51. S. Krishnan, M. Gopi, D. Manocha and M. Mine (1997). "Interactive boundary computation on boolean combinations of sculptured solids." *Computer Graphics Forum*, pp. c67-c78, vol. 16, no. 3.

52. M. Ponamgi, D. Manocha and M. Lin (1997). "Incremental algorithms for collision detection between polygonal models." *IEEE Trans. on Visualization and Computer Graphics*, vol. 3, no. 1, pp. 51-67.

53. M. C. Lin and D. Manocha (1997). "Efficient contact determination in dynamics environments." *International Journal on Computational Geometry and Applications*, (1), pp. 123-151. Special issue: Selected papers from MSI workshop on computational geometry.

54. D. Manocha and S. Krishnan (1997). "Algebraic pruning: A fast technique for curve and surface intersection." *Computer Aided Geometric Design*, vol. 20, pp, 1-23.

55. S. Kumar, D. Manocha and A. Lastra (1996). "Interactive display of large-scaled NURBS models." *IEEE Trans. On Visualization and Computer Graphics*, 2(4), pp. 323-336.

56. S. Gottschalk, M. Lin and D. Manocha (1996). "OBB-Tree: A hierarchical structure for rapid interference detection." *Proceedings of ACM SIGGRAPH'96*, pp. 171-180.

57. J. Cohen, A. Varshney, D. Manocha, G. Turk et al (1996). "Simplification envelopes." *Proceedings of ACM SIGGRAPH*, pp. 119-128.

58. S. Kumar, S. Krishnan and D. Manocha (March 1996). "Interactive display of large solid models for walkthroughs." *IEEE Computer Graphics and Applications*, pp. 9-11, (invited submission).

59. D. Manocha and S. Krishnan (1996). "Solving zero and one dimensional algebraic systems using matrix computations," *ACM SIGSAM Bulletin*, vol. 30, no. 4, pp. 4-21.

60. S. Kumar and D. Manocha (1995). "Efficient rendering of trimmed NURBS models." *Computer-Aided Design*, vol. 27, no. 7, pp. 509-521. Special issue: Visualization of surfaces.

61. D. Manocha, Y. Zhu and W. Wright (1995). "Conformational analysis of molecular chains using nano kinematics." *Computer Application of Biological Sciences*, vol. 11, no. 1, pp. 71-86. Special issue: Selected papers from 1st IEEE workshop on shape and pattern matching in computational biology.

62. D. Manocha and James Demmel (1995). "Algorithms for intersecting parametric and algebraic curves II: higher order intersections." *Computer Graphics, Vision and Image Processing*, vol. 57, no. 2, pp. 81-100.

63. M. Lin and D. Manocha (1995). "Fast interference detection between geometric models." *Visual Computer*, vol. 11, no. 10, pp. 542-561.

64. D. Manocha and John F. Canny (1994). "Efficient inverse kinematics for general 6R manipulators." *IEEE Transactions on Robotics and Automation*, vol. 10, no. 5, pp. 648-657.

65. D. Manocha (March1994). "Solving nonlinear polynomial equations." *IEEE Computer Graphics and Applications*, pp. 46-55. Special issue: Selected papers from second IEEE/ACM conference on solid modeling and applications.

66. D. Manocha and J. Demmel (1994). "Algorithms for intersecting parametric and algebraic curves I: simple intersections." *ACM Transactions on Graphics*, vol. 13, no. 1, pp. 73-100.

67. D. Manocha (1993). "Efficient algorithms for multipolynomial resultants." *The Computer Journal*, vol. 36, no. 5, pp. 485-496. Special issue on Quantifier Elimination. (invited submission).

68. D. Manocha and J. F. Canny (1993). "Multipolynomial resultant algorithms." *Journal of Symbolic Computation*, vol. 15, no. 2, pp. 99-122.

69. D. Manocha and J. F. Canny (1992). "The implicit representation of rational parametric surfaces." *Journal of Symbolic Computation*, vol. 13, 485-510.

70. D. Manocha and J. F. Canny (1992). "Algorithms for implicitizing parametric surfaces." *Computer Aided Geometric Design*, vol. 9, pp. 25-50.

71. D. Manocha and J. F. Canny (1992). "Detecting cusps and inflection points in curves." *Computer Aided Geometric Design*, vol. 9, pp. 1-24.

72. D. Manocha and J. F. Canny (1991). "A new approach for surface intersection." *International Journal of Computational Geometry and Applications*, vol. 1, no. 4, pp. 491-516. Special issue: Selected papers from first ACM conf. on solid modeling and CAD/CAM applications.

73. D. Manocha and J. F. Canny (1991). "Rational curves with polynomial parameterization." *Computer-Aided Design*, vol. 23, no. 9, pp. 645-652.

Refereed Book Chapters

74. M. Lin and D. Manocha (2004). "Efficient data structures for collision detection." *Handbook of Data Structures*, eds. D. Mehta and S. Sahni, CRC Press, 20 pages.

75. J. Cohen and D. Manocha (2004). "Model simplification." *Handbook of Visualization*, eds. C. Hansen and C. Johnson, Academic Press, 14 pages.

76. M. Lin and D. Manocha (2004). "Collision and proximity queries." *Handbook of Computational Geometry*, eds. Joe O'Rourke and T N T Goodman, CRC Press, 20 pages.

77. M. Foskey, D. Manocha, T. Culver, J. Keyser, and S. Krishnan (2002). "Reliable geometric computations with algebraic primitives and predicates." *Uncertainty in Geometric Computations*, Sheffield, Kluwer Publishers,12 pages.

78. A. Mascarenhas, S. Ehmann, A. Gregory, M. C. Lin and D. Manocha (2002). "Six Degrees-of-Freedom haptic visualization." *Touch in Virtual Environments: Haptics and the Design of Interactive Systems*, Prentice-Hall, pp.95-118.

79. M. C. Lin and D. Manocha (1998). "Applied computational geometry." *Encyclopedia of Computer Science and Technology* (invited contribution), eds. A. Kent and J. G. Williams, Marcel Dekker, Inc., 14 pages.

80. J. Keyser, S. Krishnan, D. Manocha and T. Culver (1998). "Fast and accurate boundary evaluation of sculptured solids." *IMA Conference on Mathematics of Surfaces*, vol. 8, 20 pages.

81. M. Lin, D. Manocha, J. Cohen and S. Gottschalk (1996. "Collision detection: Algorithms and applications."*Algorithmic Foundations of Robotics*, (invited submission) eds. J. Laumond and M. Overmars, pp. 129-142.

82. A. Narkhede and D. Manocha (1995). "Fast polygon triangulation based on Seidel's algorithm." *Graphics Gems V*, ed. A. Paeth, Academic Press, pp. 394-397.

83. D. Manocha (1994). "Solving polynomial systems using matrix computations." *Advances in Computational Mathematics*, eds. H.P. Dikshit and C.A. Micchelli, World Scientific, pp. 99-130.

84. D. Manocha, A. Varshney and H. Weber (1994). "Evaluating surface intersections in lower dimension." *Curves and Surfaces*, eds. Laurent et al., A K Peters, Wellesley, MA., pp. 327-334.

85. M. C. Lin and D. Manocha (1993). "Interference detection between curved objects for computer animation." *Models and Techniques for Computer Animation*, eds. N.M. Thalmann and D. Thalmann, Springer-Verlag, pp. 43-57.

86. D. Manocha and B. A. Barsky (1991). "Varying the shape parameters of rational continuity." *Curves and Surfaces*, eds. P. Laurent, A. Le Mehaute and L. Schumaker, Academic Press, Boston, pp. 307-314.

87. D. Manocha and J. F. Canny (1991). "Detecting cusps and inflection points in curves." *Curves and Surfaces*, eds. P. Laurent, A. Le Mehaute and L. Schumaker, Academic Press, Boston, pp. 315-319.

88. D. Manocha and J. F. Canny (1990). "Algorithms for implicitizing parametric surfaces." *The Mathematics of Surfaces*, eds. A. Bowyer, Oxford University Press, vol. 4, pp. 97-131.

Refereed Conference Publications ***(including ACM SIGMOD, ACM Multimedia, ACM SuperComputing & Robotics Conferences)***

89. N. Govindaraju, J. Gray, R. Kumar and D. Manocha, "GPUTeraSort: High performance graphics coproeessor sorting for large database management", *Proc. of ACM SIGMOD*, 2006.

90. G. Varadhan, S. Krishnan, L. Zhang and D. Manocha, "Reliable implicit surface polygonization using visibility mapping", *Proc. of Symposium on Geometry Processing*, 2006.

91. L. Zhang, Y. Kim, and D. Manocha, "A simple path non-existence algorithm using C-obstacle query", *Proc. of Workshop on Algorithmic Foundations of Robotics*, 2006.

92. B. Lloyd, D. Tuft., S. Yoon and D. Manocha, "Warping and Partitioning for Low Error Shadow Maps", *Proc. Of Eurographics Symposium on Rendering*, 2006.

93. G. Varadhan and S. Krishnan and D. Manocha, "Reliable adaptive dynamics with efficient contact handling of articulated models", *Proc. of Robotics: Science and Systems*, 2006.

94. R. Gayle, M. Lin and D. Manocha, "Adaptive dynamics with efficient contact handling of articulated models", *Proc. of Robotics: Science and Systems*, 2006.

95. N. Govindaraju, S. Larsen, J. Gray, and D. Manocha, "An efficient memory model for scientific algorithms on graphics processors", *Proc. of ACM SuperComputing,*, 2006.

96. L. Zhang, Y. Kim, G. Varadhan and D. Manocha, "Fast C-obstacle query computation for motion planning", *Proc. of IEEE Conf. on Robotics and Automation*, 2006.

97. L. Zhang, Y. Kim, G. Varadhan and D. Manocha, "Generalized penetration depth computation", *Proc. of ACM Solid and Physical Modeling*, 2006.

98. G. Varadhan, Y. Kim, S. Krishnan and D. Manocha, "Topology preserving approximation of free configuration space", *Proc. of IEEE Conf. on Robotics and Automation*, 2006.

99. A. Sud, N. Govindraju, R. Gayle and D. Manocha, "Interactive 3D distance field computation using linear factorization", *Proc. of ACM Symposium on Interactive 3D Graphics*, 2006

100. N. Govindaraju, I. Kabul, M. Lin and D. Manocha, "Fast continuous collision detection among deformable models using graphics processors", *Proc.. of Eurographics Symposium on Virtual Environments*, 2006.

101. N. Govindaraju, M. C. Lin and D. Manocha (2005). "Quick-CULLIDE: Fast inter-and intra-Object collision culling using graphics hardware." *Proc. of IEEE Virtual Reality.* **Received best paper award.**

102. Nico Galoppo, N. Govindaraju, M. Henson and D. Manocha. "LU-GPU: Efficient algorithms for solving dense linear systems on graphics hardware", Proc. of *IEEE/ACM SuperComputing* 2005 (to appear).

103. G. Varadhan and D. Manocha (2005). "Star-shaped roadmaps: A deterministic sampling approach for complete motion planning." *Proc. of Robotics: Science and Systems*, 8 pages.

104. A. Sud, N. Govindaraju and D. Manocha (2005), "Interactive computation of discrete generalized Voronoi diagrams using range culling", Proc. of *Voronoi Diagrams '05.*

105. N. Govindaraju and D. Manocha (2005). "Efficient relational database management on graphics processors", ACM Workshop on Data Management on New Hardware, 2005 (Invited paper), 8 pages.

106. R. Gayle, P. Segars, M. Lin and D. Manocha (2005). "Path planning for deformable robots in complex environments." *Proc. of Robotics: Science and Systems,* 8 pages.

107. S. Yoon, P. Lindstrom, V. Pascucci and D. Manocha, "Cache-Oblivious layouts of Polygonal Meshes", *Workshop on Massive Geometric Data Sets*, 2005, 6 pages.

108. A. Sud, M. Foskey and D. Manocha (2005). "Homotopy-preserving medial axis simplification." *Proc. of ACM Symposium on Solid and Physical Modeling,* 12 pages..

109. N. Govindaraju, N. Raghuvanshi and D. Manocha (2005). "Fast and approximate stream mining of quantiles and frequencies using graphics processors." *Proc. of ACM SIGMOD*, 12 pages.

110. M. Verdesca, J. Munro, M. Hoffman, M. Bauer and D. Manocha (2005). "Using Graphics Processor Units to Accelerate OneSAF: A Case Study in Technology Transition." *Proc. of I/ITSEC, 8 pages.*

111. R. Gayle, M. C. Lin and D. Manocha (2005). "Constraint-based motion planning of deformable robots." *Proc. of IEEE Int. Conf. on Robotics and Automation*, 8 pages.

112. N. Govindaraju, M. Henson, M. C. Lin and D. Manocha (2005). "Interactive visibility ordering and transparency ordering among geometric primitives in complex environments." *Proc. of ACM Symposium on Interactive 3D Graphics and Games,* 8 pages.

113. S. Redon. Y. Kim, M. C. Lin and D. Manocha (2004). "Fast continuous collision detection for articulated models." *Proc. of ACM Solid Modeling*, 12 pages.

114. Lloyd, J. Wendt, N. Govindaraju and D. Manocha (2004). "CC shadow volumes." *Proc. of Eurographics Symposium on Rendering*, 8 pages.

115. N. Govindaraju, B. Lloyd, W. Wang, M. Lin and D. Manocha (2004). "Fast database computations using graphics hardware." *Proc. of ACM SIGMOD*, 12 pages.

116. G. Varadhan, S. Krishnan, T.V.N Sriram and D. Manocha.(2004) "Topology preserving surface extraction using adaptive subdivision." *Proc. of Second Eurographics Symposium on Geometry Processing*, 10 pages.

117. S.Yoon, B. Salomon, M. C. Lin, and D. Manocha (2004). "Fast collision detection between massive models using dynamic simplification." *Proc. of Second Eurographics Symposium on Geometry Processing*, 10 pages.

118. G. Varadhan, S. Krishnan, T.V.N Sriram and D. Manocha (2004). "A simple algorithm for complete motion planning of translating polyhedral robots." *Proc. of Sixth International Workshop on the Algorithmic Foundations of Robotics*, 12 pages.

119. S. Yoon, B. Salomon, R. Gayle and D. Manocha (2004). "Quick-VDR: Interactive view-dependent rendering of massive models." *Proc. of IEEE Visualization*, 8 pages.

120. G. Varadhan and D. Manocha (2004). "Accurate minkowski sum approximation of polyhedral models." *Proc. of Pacific Graphcis,* 8 pages. ***Received Best Paper Award.***

121. N. Govindaraju, M. C. Lin and D. Manocha (2004). "Fast and reliable collision culling using graphics processors." *Proc. of ACM VRST*, 8 pages.

122. S. Redon, Y. Kim, M. C. Lin and D. Manocha, J. Templeman (2004). "Interactive continuous collision detection for avatars in virtual environments." *Proc. Of IEEE Virtual Reality*, 8 pages.

123. N. K. Govindaraju, A. Sud, S. Yoon and D. Manocha (2003). "Interactive visibility culling for complex environments using occlusion-switches." *Proc. of ACM SIGGRAPH Symposium on Interactive 3D Graphics*, 11 pages.

124. M. Foskey, M. Lin and D. Manocha (2003). "Efficient computation of a simplified medial axis." *Proc. of ACM SIGGRAPH Sympoisum on Solid Modeling*, pp. 96-107.

125. Y. Kim, G. Varadhan, M. Lin and D. Manocha (2003). "Fast approximation of swept volumes of complex polyhedral models." *Proc. of ACM SIGGRAPH Symposium on Solid Modeling*, pp. 11-22. **Received best conference paper award.**

126. B. Salomon, M. Garber, M. Lin and D. Manocha (2003). "Interactive navigation in complex environments using path planning." *Proc. of ACM SIGGRAPH Symposium on Interactive 3D Graphics*, 11 pages.

127. S. Yoon, B. Salomon and D. Manocha (2003). "Interactive view-dependent rendering with conservative occlusion culling in complex environments." *Proc. of IEEE Visualization*, 8 pages.

128. G. Varadhan, S. Krishnan, Y. J Kim and D. Manocha (2003). "Feature-sensitive subdivision and iso-surface reconstruction." *Proc. of IEEE Visualization*, 8 pages.

129. D. Manocha (2003), "Interactive display of complex environments", *Proc. of I/ITSEC*, 8 pages (invited submission).

130. G. Varadhan, S. Krishnan, Y. J Kim, S. Diggavi, and D. Manocha (2003). "Efficient max-norm distance computation and reliable voxelization." *Proc. of ACM/Eurographics Symposium on Geometry Processing*, 12 pages.

131. N. Govindraju, S. Redon, M. Lin and D. Manocha (2003). "CULLIDE: Interactive collision detection between complex models in large environments using graphics hardware." *Proc. of ACM/Eurographics Workshop on Graphics Hardware*, 10 pages.

132. Y. Kim, M. Lin and D. Manocha (2002). "DEEP: Dual-space expansion for estimating penetration depth between convex Polytopes." *Proc. of IEEE Conference on Robotics and Automation.*

133. Y. J. Kim, M. C. Lin and D. Manocha (December 2002). "Fast penetration depth estimation using rasterization hardware and hierarchical refinement." *Proc. of Workshop on Algorithmic Foundation on Robotics.*

134. J. Keyser, T. Culver, M. Foskey, S. Krishnan, and D. Manocha (2002). "ESOLID- A system for exact boundary evaluation. *Pro.s of the ACM Conference on Solid Modeling.*

135. Y. J. Kim, M. A. Otaduy, M. C. Lin and D. Manocha (July 2002). "Fast penetration depth computation for physically-based animation." *Proc. of ACM SIGGRAPH Symposium on Computer Animation.*

136. N. Govindaraju, A. Sud, S. Yoon and D. Manocha (October 2002). "Parallel occlusion culling for interactive walkthroughs using multiple GPUs." *Proc. of Workshop on Commodity-Based Visualization Clusters.*

137. D. Gotz, K. Mayer-Patel and D. Manocha (2002). "IRW: Incremental representation for image-based walkthroughs." *Proc. of ACM Multimedia.*

138. B. Baxter, A. Sud, N. Govindraju and D. Manocha (2002). "GigaWalk: Interactive walkthrough of complex 3D environments." *Proc. of Eurographics Workshop on Rendering.*

139. G. Varadhan and D. Manocha (2002). "Out-of-core rendering of massive geometric datasets." *Proc. of IEEE Visualization.*

140. Y. Kim, M. Otaduy, M. Lin and D. Manocha (2002). "Six-degree-of-freedom haptic display using localized contact computations." *Proc. of Tenth Symposium on Haptic Interfaces For Virtual Environment and Teleoperator Systems*.

141. M. Foskey, M. Garber, M. Lin and D. Manocha (2001). "A Voronoi-based hybrid motion planner for rigid bodies." *Proc. of International Conference on Intelligent Robots and Systems*.

142. A. Wilson, K. Mayer-Patel and D. Manocha (2001). "Spatially-encoded far-field representations for interactive walkthroughs." *Proc. of ACM Multimedia*, pp. 348-357. **Received Best Paper Award**.

143. C. Erikson, D. Manocha and B. Baxter (2001). "HLODs for faster display of large static and dynamic environments." *Proc. of ACM Symposium on Interactive 3D Graphics*.

144. K. Hoff, A. Zaferakis, M. Lin and D. Manocha (2001). "Fast and simple 2D geometric proximity queries using graphics hardware." *Proc. of ACM Symposium on Interactive 3D Graphics*.

145. S. Krishnan, M. Foskey, T. Culver, J. Keyser and D. Manocha (2001). "PRECISE: Efficient multiprecision evaluation of algebraic roots and predicates for reliable geometric computation." *Proc. of ACM Symposium on Computational Geometry*, pp. 274-283.

146. A. Gregory, A. Mascarenhas, S. Ehmann, M. C. Lin and D. Manocha (2000). "6-DOF haptic display of polygonal models." *Proc. of IEEE Visualization*.

147. A. Wilson, M. Lin, D. Manocha, B. Yeo and M. Yeung (2000). "A video-based rendering acceleration algorithms for interactive walkthroughs." *Proc. of ACM Multimedia*, pp. 75-84.

148. C. Pisula, K. Hoff, M. Lin and D. Manocha (2000). "Randomized path planning for a rigid body based on hardware accelerated voronoi sampling." *Proc. of 4th International Workshop on Algorithmic Foundations of Robotics*, 18 pages.

149. K. Hoff, T. Culver, J. Keyser, M. Lin and D. Manocha (2000). "Interactive motion planning using hardware accelerated computation of generalized voronoi diagrams." *Proc. of IEEE International Conference on Robotics and Automation*.

150. E, Larsen, S. Gottschalk, M. Lin and D. Manocha (2000). "Fast distance queries using rectangular swept sphere volumes." *Proc. of IEEE International Conference on Robotics and Automation*.

151. D. Aliaga, J. Cohen, A. Wilson, E. Baker, H. Zhang, C. Erikson, K. Hoff, T. Hudson, W. Stuerzlinger, R. Bastos, M. Whitton, F. Brooks and D. Manocha (1999). "A framework for the real-time walkthrough of massive models." *Proc. of ACM Symposium on Interactive 3D Graphics*.

152. C. Erikson and D. Manocha (1999). "GAPS: general and automatic polygon simplification." *Proc. of ACM Symposium on Interactive 3D Graphics*.

153. T. Culver, J. Keyser and D. Manocha (1999). "Accurate computation of medial axis of a polygon." *Proc. of ACM Symposium on Solid Modeling.*

154. A. Wilson, D. Manocha and M. Lin (1999). "Representation and interactive manipulation of massive CAD datasets." *Proc. of Workshop on Integrated Spatial Databases: Digital Images and GIS.*

155. J. Keyser, T. Culver, S. Krishnan and D. Manocha (1999). "MAPC: A library for efficient and exact manipulation of algebraic points and curves." *Proc. of ACM Symposium on Computational Geometry.*

156. Gopi and D. Manocha (1998). "A unified approach for simplifying polygonal and spline models." *Proc. of IEEE Visualization'98*, pp. 271-278.

157. S. Krishnan, A. Pattekar, M. Lin and D. Manocha (1998). "Spherical Shell: A higher order bounding volume for fast proximity queries." *Proc. of Third Workshop on Algorithmic Foundations of Robotics.*

158. A. Wallack, I. Emiris, and D. Manocha (1998). "MARS: Maple/Matlab resultant-based solver." *Proc. of ACM International Symposium on Symbolic and Algebraic Computing*, pp. 244-251.

159. A. Gregory, A. State, M. Lin, D. Manocha and M. Livingston (1998). "Polyhedral morphing using feature-based surface decomposition." *Proc. of Computer Animation*, pp. 64-71.

160. J. Cohen, D. Manocha and M. Olano (1997). "Simplifying polygonal models using successive mappings." *Proc. of IEEE Visualization'97*, pp. 395-402.

161. S. Kumar, D. Manocha, H. Zhang and K. Hoff (1997). "Accelerated walkthrough of large spline models." *Proc. of ACM Symposium on Interactive 3D Graphics*, pp. 91-102.

162. T. Hudson, D. Manocha, J. Cohen, M. Lin, K. Hoff and H. Zhang (1997). "Accelerated occlusion culling using shadow frusta." *Proc. of ACM Symposium on Computational Geometry*, pp. 1-10.

163. J. Keyser, S. Krishnan and D. Manocha (1997). "Efficient boundary computation of low degree sculptured solids using exact arithmetic." *Proc. of ACM Symposium on Solid Modeling*, pp. 42-55.

164. T. Hudson, M. Lin, J. Cohen, S. Gottschalk and D. Manocha (1997). "V-COLLIDE: Accelerated collision detection for VRML." *Proc. of VRML'97 conference*, pp. 119-125.

165. S. Kumar, C. Chang and D. Manocha (1996). "Scalable algorithms for interactive visualization of curved surfaces." *Proc. of Supercomputing'96*, 10 pages. **Received best student paper award.**

166. S. Krishnas and D. Manocha (1996). "Computing boolean combinations of solids composed of free-form surfaces." *Proc. of ASME Conf. on Design and Manufacturing*, 10 pages.

167. S. Krishnan and D. Manocha (1996). "Algebraic loop detection and evaluation algorithms for curve and surface interrogations." *Proc. of Graphics Interface'96*, pp. 87-94.

168. S. Kumar and D. Manocha (1996). "Hierarchical visibility culling for spline models." *Proc. of Graphics Interface'96*, pp. 142-150.

169. S. Kumar, D. Manocha, W. Garrett and M. Lin (1996). "Hierarchical back-face culling." *Proc. of 7th Eurographics Workshop on Rendering*, Porto, Portugal, pp. 231-240.

170. S. Krishnan and D. Manocha (1996). "Efficient representations and techniques for computing B-rep's of CSG models with NURBS primitives", *Proc. of CSG'96*, Winchester, England, pp. 101-122.

171. M. Hughes, M. Lin, D. Manocha and C. Dimattia (1996). "Efficient and accurate interference detection for polynomial deformation and soft object animation." *Proc. of Computer Animation'96*, IEEE Computer Society, pp. 155-166.

172. S. Kumar and D. Manocha (1996). "Dynamic mesh generation for parametric iso-surfaces." *Proc. of 5th International Conference on Numerical Grid Generation in Computational Fluid Dynamics and Related Fields*, pp. 303-312, Starkville, MS.

173. S. Krishnan and D. Manocha (1995). "Numeric-symbolic algorithms for evaluating one-dimensional algebraic sets." *Proc. of ACM International Symposium on Symbolic and Algebraic Computation*, pp. 59-67, Montreal, Canada.

174. K. Ponamgi, D. Manocha and M. Lin (1995). "Incremental algorithms for collision detection between solid models." *Proc. of ACM/Siggraph Conference on Solid Modeling and Applications*, pp. 293-304, Salt Lake City, UT.

175. S. Kumar, S. Krishnan, D. Manocha and A. Narkhede (1995). "High speed and high fidelity visualization of complex CSG models." *Proc. of BCS International Conference on Visualization and Modeling*, pp. 203-222 Leeds, England.

176. A. Varshney, F. Brooks, D. Richardson, W. Wright and D. Manocha (1995). "Defining, computing, and visualizing molecular interfaces." *Proc. of IEEE Visualization'95*, pp. 36-43.

177. S. Krishnan, A. Narkhede and D. Manocha (1995). "Representation and Computation of Boolean operations of sculptured models." *Proc. of ACM Conference on Computational Geometry*, pp. C8-C9.

178. J. Cohen, M. Lin, D. Manocha and K. Ponamgi (1995). "I-COLLIDE: An interactive and exact collision detection system for large-scale environments." *Proc. of ACM Interactive 3D Graphics Conference*, pp. 189-196, Monterey, CA.

179. S. Kumar, D. Manocha and A. Lastra (1995). "Interactive display of large-scale NURBS models." *Proc. of ACM Interactive 3D Graphics Conference*, pp. 51-58, Monterey, CA.

180. M. C. Lin, D. Manocha and M.K. Ponamgi (1995). "Fast algorithms for penetration and contact determination between non-convex polyhedral models." *Proc. of IEEE Conference on Robotics and Automation*, pp. 2707-2712, Nagoya, Japan.

181. D. Manocha and Y. Zhu (1994). "Kinematic manipulation of molecular chains subject to rigid constraints." *Proc. of Second International Conference on Intelligent Systems for Molecular Biology*, pp. 285-294, Stanford, CA.

182. D. Manocha (1994). "Computing selected solutions of polynomial systems." *Proc. of ACM International Symposium on Symbolic and Algebraic Computation*, pp. 1-8, Oxford, England.

183. J. Cohen, M. Lin, D. Manocha and K. Ponamgi (1994). "Efficient collision detection for interactive environments." *Proc. of 10th ACM Computational Geometry Conference*, pp. 391-392, Stony-Brook, NY.

184. D. Manocha, Y. Zhu and W. Wright (1994). "Conformational analysis of molecular chains using nano-kinematics." *Proc. of IEEE Computer Society Workshop on Shape and Pattern Matching in Computational Biology*, pp. 3-29, Seattle, WA.

185. M. Lin, D. Manocha and J. Canny (1994). "Fast contact determination in dynamic environments." *Proc. of IEEE Conference on Robotics and Automation*, pp. 602-608, San Diego, CA.

186. D. Manocha and Y. Zhu (1994). "A fast algorithm and system for the inverse kinematics of general serial manipulators." *Proc. of IEEE Conference on Robotics and Automation*, pp. 3348-3354, San Diego, CA.

187. A. Wallack, J. Canny and D. Manocha (1993). "Object recognition using cross beam sensing." *Proc. of IEEE Conference on Robotics and Automation*, pp. 692-699, Atlanta, GA.

188. D. Manocha (1993). "Solving polynomial systems for curve, surface and solid modeling." *Proceedings of ACM/SIGGRAPH Conference on Solid Modeling'93*, pp. 169-178, Montreal, Canada.

189. D. Manocha (1992). "Robust techniques for curve and surface intersections." *Proc. of SPIE Conference on Curves and Surfaces in Computer Vision and Graphics III*, pp. 58-69 (invited paper).

190. D. Manocha and J. F. Canny (1992). "Real time inverse kinematics for general 6R manipulators." *Proc. of IEEE Conference on Robotics and Automation*, pp. 383-389, Nice, France.

191. D. Manocha and James Demmel (1992). "Intersecting parametric and algebraic curves." *Proc. of Graphics Interface'92*, pp. 232-241, Vancouver, British Columbia.

192. D. Manocha and J. F. Canny (1992). "Multipolynomial resultant algorithms and linear algebra." *Proc. of International Symposium on Symbolic and Algebraic Computation*, pp. 158-167, Berkeley, California.

193. D. Manocha and J. F. Canny (1992). "Efficient inverse kinematics for general serial manipulators." *Proc. of Japan-USA symposium on flexible automation*, pp. 125-131, San Francisco, CA.

194. D. Manocha and J. F. Canny (1991). "A new approach for surface intersection." *Proc. of First ACM Conference on Solid Modeling and CAD/CAM*, pp. 209-220, Austin, Texas.

195. D. Manocha and J. F. Canny (1991). "Efficient techniques for multipolynomial resultant algorithms." *Proceedings of International Symposium on Symbolic and Algebraic Computation*, pp. 86-95, Bonn, Germany.

196. D. Manocha and J. F. Canny (1991). "MultiPolynomial resultant algorithms." *Proc. of International Conference on Intelligent Robotics*, pp. 348-358, Bangalore, India.

197. D. Manocha and B. A. Barsky (1991). "Varying the shape parameters of rational continuity." *Proc. of IMACS'91*, pp. 203-207, Dublin, Ireland.

198. D. Manocha (1990). "Regular curves and proper parametrizations." *Proc. of International Symposium on Symbolic and Algebraic Computation*, pp. 271-276, Tokyo, Japan.

199. D. Manocha and B. A. Barsky (1990). "Basis functions for rational continuity." *Proc. of Computer Graphics International '90*, eds. T.S. Chua and T.L. Kunii, pp. 521-542, Springer-Verlag.

200. D. Manocha and J. F. Canny (1990). "Rational curves with polynomial parametrizations." *Proc. of SPIE conference on Curves and Surfaces for Computer Vision and Graphics*, pp. 151-162.

Refereed Video Publications

201. N. Govindaraju, M. C. Lin and D. Manocha (2005). ``Reliable Collision Culling using Graphics Processors", *Proc. of 21st ACM Computational Geometry Conference, Video Publication*.

202. Y. J. Kim, M. Otaduy, M. C. Lin and D. Manocha (2003). "Fast penetration depth estimation using rasterization hardware and hierarchical refinement." *Proc. of 19th ACM Computational Geometry Conference, Video Publication*.

203. K. Hoff, T. Culver, J. Keyser, M. Lin and D. Manocha (2000). "Fast computation of generalized voronoi diagrams using graphics hardware." *Proc. of 16th ACM Computational Geometry Conference, Video Publication*.

204. Gregory, A. State, M. Lin, D. Manocha and M. Livingston (1999). "Feature-based surface decomposition for polyhedral morphing." *Proc. of 15th ACM Computational Geometry Conference*, Video Publication.

205. Wilson, E. Larsen, D. Manocha, and M. Lin (1999). "Graph partitioning and ordering for interactive proximity queries." *Proc. of 15th ACM Computational Geometry Conference*, Video Publication.

206. S. Kumar, D. Manocha, W. Garrett and M. Lin (1997). "Hierarchical backface computation." *Proc. of 13th ACM Computational Geometry Conference*, Video Publication, v11-12.

207. S. Kumar and D. Manocha (1996). "The power of coherence: Fast tessellation of surfaces." *Proc. of 12th ACM Computational Geometry Conference*, Video Publication, pp. v17-18.

208. K. Ponamgi, D. Manocha and M. Lin (1995). "Incremental collision detection between solid models." *Proc. of 11th ACM Computational Geometry Conference*, Video Publication, pp. v7-8.

209. J. Cohen, M. Lin, D. Manocha and K. Ponamgi (1994). "Efficient collision detection for interactive environments." *Proc. of 10th ACM Computational Geometry Conference*, Video Publication, pp. 391-392, Stony Brook, NY.

GRADUATE STUDENTS

Currently Supervised

1. Lasar Askew (in progress)
2. Sean Curtis (in progress)
3. Russell Gayle (in progress) (jointly with Ming C. Lin)
4. Christian Lauterbach (in progress)
5. Brandon Lloyd (in progress)
6. Brian Salomon (in progress)
7. Avneesh Sud (in progress)
8. Liangjun Zhang (in progress)

Ph.D. Students Graduated

1. Jonatham Cohen (Ph.D. December '98). First Appointment: Assistant Professor at Johns Hopkins University
2. Tim Culver (Ph.D. Fall'00). First Appointment: Think3 Inc.
3. Carl Erikson (Ph.D. Spring'00). First Appointment: BOPS Inc.
4. Stefan Gottschalk (Ph.D. Summer'00; Co-Supervised with Ming Lin). First Appointment: Nvidia Inc.
5. Naga Govindraju (Ph.D. Summer'04). First Appointment: Research Assistant Professor, UNC Chapel Hill.
6. John Keyser (Ph.D. Summer'00). First Appointment: Assistant Professor at Texas A&M University.
7. Shankar Krishnan (Ph.D. July '97). Member of Technical Staff, AT&T Research Labs.
8. Subodh Kumar (Ph.D. Fall '96). First Appointment: Assistant Professor, Johns Hopkins University
9. Gokul Varadhan (Ph.D. Fall'05): First Appointment: Postdoc at UNC Chapel Hill
10. Andrew Wilson (Ph.D. Fall'02). First Appointment: Sandia National Labs
11. Sungeui Yoon (Ph.D. Fall'05): First Appointment: Lawrence Livermore Labs
12. Hansong Zhang (Ph.D. Fall '98). First Appointment: Silicon Graphics.

M.S. Students Graduated

1. Bill Baxter (M.S. Spring'01): OLM Digital
2. Mark Foskey (M.S. Spring'01). First Appointment: Research Faculty at UNC Chapel Hill.
3. Sean Hanlon (M.S. Spring'05): Constella Group
4. Karl Hillesland (M.S. Spring'02): ATI

5. Tom Hudson (M.S. Summer'97). UNC Wilmington.
6. Kenny Hoff (M.S. Summer'99). Silicon Graphics
7. Wesley Hunt (M.S. Spring'00): iRock inc.
8. Eric Larsen (M.S. Spring'99). Sony.
9. Gopi Meenakshi (M.S. Spring'99): UC Irvine
10. Atul Narkhede (M.S. Spring '95). Silicon Graphics.
11. David O'Brien (M.S. Spring'01): UNC Chapel Hill
12. Amol Pattekar (M.S. Spring'98). Yahoo Inc.
13. Kris Ponamgi (M.S. Fall '95). Virtus Inc.
14. Kyle Wilson (M.S. Summer '97). Interactive Magic.
15. Andrew Zaferakis (M.S. Spring'02). TriLunar Inc.

POSTDOCS

Currently Supervised

Vivek Kwatra (co-supervised with Ming C. Lin)

Postdocs Previously Supervised

1. Mark Foskey (Co-Supervised with Ming C. Lin). Research Assistant Professor, UNC Chapel Hill.
2. Young Kim (Co-Supervised with Ming C. Lin). Assistant Professor, Enwa University, S. Korea.
3. Gokul Varadhan: Currently a member of Technical Staff at Google Inc.

PH.D. COMMITTEES

1. Rui Bastos (Ph.D. 1999)
2. Michael Bajura (Ph.D. 1997)
3. Deepak Bandophaday (Ph.D. 2005)
4. William Baxter (Ph.D. 2004)
5. David Chen (Ph.D. 1998)
6. Fredo Durand (Univ. of Grenoble, France) (Ph.D. 1999)
7. David Eberly (Ph.D. 1994)
8. Jacob Furst (Ph.D. 1999)
9. Karl Hillesland (Ph.D. 2005)
10. Martin Isenburg (Ph.D. 2004)
11. Robert Katz (Ph.D. 2002)
12. Ted Kim (Ph.D. 2006)
13. Kok-Lim Low (Ph.D. 2005)
14. Yunshan Liu (in progress)
15. David Luebke (Ph.D. 1998)
16. Ajith Masceranhas (Ph.D. 2005)
17. Manfred Minimair (Math Department, NC State, Spring 2001)
18. Miguel Otaduy (Ph.D. 2004)
19. Voicu Popescu (Ph.D. 2001)
20. John Rhoades (Ph.D. 1993)
21. Paul Segars (Bio-Medical Engineering Department) (Ph.D. 2001)
22. Timothy Terriberry (in progress)

23. Andrew Thall (Ph.D. 2004)
24. Amitabh Varshney (Ph.D. 1994)
25. Kelly Ward (Ph.D. 2005)
26. Yunshan Zhu (Ph.D. 1998)

M.S. COMMITTEES

- Daniel Aliaga (M.S. 1993)
- Audra Sugerman (M.S. 1995)
- Atul Narkhede (M.S. 1995)
- Kris Georges (M.S. 1995)

REFEREE FOR

- ACM Transactions on Graphics
- Journal of Symbolic Computation
- Computer Vision, Graphics and Image Processing
- Presence
- IEEE Computer Graphics and Applications
- Computer
- Computer-Aided Design
- Computer Aided Geometric Design
- SIAM Journal on Computing
- Applicable Algebra in Engineering, Communication and Computing
- Journal of Robotics System
- International Journal of Computational Geometry and Applications
- IEEE Transactions on Robotics and Automation
- IEEE International Conference on Robotics and Automation
- Computer Graphics Forum
- ACM SIGGRAPH
- ACM Interactive 3D Graphics Conference
- ACM/SIGGRAPH Solid Modeling Conference
- ACM Volume Visualization Symposium
- IEEE Visualization
- Graphics Interface
- EuroGraphics
- AAECC (Applied Algebra and Error Correcting Codes)
- ACM Symposium on Computational Geometry
- International Conference on Robotics & Automation
- International Symposium on Symbolic and Algebraic Computation
- Army Research Office Proposals
- National Science Foundation Proposals
- National Research Council

INVITED COLLOQUIA

- **Interactive Rendering of Massive Models: Rasterization or Ray Tracing**
  1. Aiya Napa Seminar, Cyprus, June 2006
  2. Department of Computer Science, University of Stuttgart, July 2006

- **Real-Time Display & Walkthroughs of Massive Models**
  1. Pacific Graphics, October 2005
  2. Institute of Creative Technologies, September, 2004.
  3. Department of Computer Science, ETH, Swiss Federal Institute of Technology, Zurich, July 2004.
  4. ONR PI Meetings, Naval Research Labs, 2000-2004
  5. Department of Computer Science, University of Maryland, May 2003.
  6. Intel, Oregon, August 2002.
  7. ARMY STRICOM, March 2000.
  8. Department of Computer Science, USC, February 2000.
  9. Department of Computer Science, UCSD, November 1999.
  10. Institute of Creative Technologies, USC, November 1999.
  11. Department of Computer Science, UCLA, May 1999.
  12. Lawrence Livermore National Labs, Livermore, March 1999.
  13. Department of Computer Science, New York University, October 1998.
  14. NASA Ames, Mountain View, CA, August 1998.
  15. Interval Research, Palo Alto, CA, July 1998.
  16. Hewlett-Packard Research Labs, Palo Alto, CA, June 1998.
  17. Intel, Santa Clara, CA, June 1998.

- **General Purpose Computation using Graphics Processors**
  1. MATREX Meeting, RDECOM, February, 2006
  2. SAIC, November 2005
  3. Hong Kong University of Science and Technology (HKUST), October 2005
  4. Workshop on High Performance Embedded Computing, September 2005
  5. Intel, Santa Clara, August 2005
  6. Army Research Labs, July 2005
  7. Army Modeling and Simulation Office, July 2005
  8. High Performance Computing Symposium, June 2005
  9. MERL, Cambridge, MA, June 2005
  10. Army CERDEC, New Jersey, June 2005
  11. Department of Computer Science, University of California at Irvine, September 2004.
  12. National Simulation Center, February 2004
  13. Intel, Oregon, October 2003.
  14. I/ITSEC, November 2004
  15. PEO STRI, May 2003
  16. RDECOM, STTC, Orlando, May 2003

- **Exact and Accurate Computations with non-linear Algebraic primitives**
  - Max-Planck Institute, Saarbrucken, Germany, June 2002.

- **Collision Detection between Rigid and Deformable Models**
  - Workshop on Surgical Simulation, Stanford, CA, 2001.

- **MultiPolynomial Resultants: Algorithms, Implementation and Applications**

1. US Naval Academy, Annapolis, MD, May 1996.
2. Invited speaker, East Coast Computer Algebra Day, IBM TJ Watson Research Center, April 1996.

- **Collision Detection: Algorithms and Applications**
  - Invited minisymposium speaker, SIAM Conference on Geometric Design, November 1995.
  - Second Workshop on Algorithmic Robotics, Toulouse, France, July 1996.

- **Towards Interactive Walkthrough of large CAD models**
1. National Institute of Standards and Technology, Gaithersburg, MD, March 1997.
2. State University of New York at Stony Brook, March 1997.
3. University of Michigan, Ann Arbor, MI, March 1997.
4. Northwestern University, February, 1997.
5. National Institute of Standards and Technology, Gaithersburg, MD, June 1995.
6. Workshop on Geometric Software and Visualization, Princeton, NJ, June 1996.
7. Invited speaker, Graphicon'96 conference, St. Petersburg, July 1996.
8. Invited speaker, First CGC Workshop on Computational Geometry, John Hopkins University, October 1996.

- **Modeling and Rendering with Algebraic Constraints**
1. AT&T Bell Labs, Murray Hill, NJ, May 1995.
2. University of California at Davis, CA, April 1995.
3. Naval Postgraduate School, Monterey, CA, April 1995.
4. Princeton University, Princeton, NJ, April 1995.
5. University of Utah, Salt Lake City, UT, March 1995.
6. University of Florida, Gainesville, FL, March 1995.

- **Interactive Model Construction, Display and Collision Detection for Virtual Environments**
  - ONR PI's meeting, Arlington, VA, March 1995.

- **Geometric Problems in the Non-linear World**
  - Invited speaker, Geometry software workshop, University of Minnesota, MN, January 1995.

- **Geometric and Solid Modeling**
  - Invited colloquium, Indian Institute of Technology, N. Delhi, India, January 1994.

- **Non-Linear Polynomial Equations and Matrix Computations**
  - Invited speaker, "Advances in Computational Mathematics", N. Delhi, India, January 1994.

- **Surface Intersection in Lower Dimensions**
  - Invited minisymposium speaker, SIAM Conference on Geometric Design, Tempe, AZ, November 1993.

- **Modeling with Algebraic Constraints**
1. University of Geneva, Geneva, Switzerland, June 1993.
2. INRIA, Nice, France, June 1993.
3. Department of Computer Science, Duke University, Durham, NC, February 1993.
4. Department of Computer Science, University of North Carolina at Chapel Hill, NC, February 1993.

- **Robust Methods for Curve and Surface Intersection**

- Invited presentation, SPIE Conference on Curves and Surfaces for Computer Graphics and Vision, Boston, MA, November 1992.

- **Non-Linear Geometry and Linear Algebra**
  1. Mitsubishi Electric Research Lab, Cambridge, MA, April 1992.
  2. Department of Computer Science, University of North Carolina at Chapel Hill, NC, April 1992.
  3. School of Computer Science, Carnegie Mellon University, Pittsburgh, PA, April 1992.
  4. College of Computing, Georgia Institute of Technology, Atlanta, GA, April 1992.
  5. Department of Computer Science, University of Toronto, Toronto, Canada, March 1992.
  6. Department of Computer Science, State University of New York, Stony Brook, NY, March 1992.
  7. Department of Computer Science, University of Maryland at College Park, MD, March 1992.
  8. Department of Computer Science, University of California at Santa Barbara, CA, March 1992.
  9. Department of Computer Science, University of Minnesota, Minnesota, MN, March 1992.
  10. Department of Computer Science, University of Waterloo, Waterloo, Canada, March 1992.
  11. Department of Computer and Information Science, University of California at Santa Cruz, CA, February 1992.
  12. IBM TJ Watson Research Center, Yorktown Heights, NY, February 1992.

- **Algorithms for curve and surface intersections**
  - Invited colloquium, Xerox Palo Alto Research Center, Palo Alto, CA, February 1992.

- **Efficient techniques for implicitization**
  - Invited presentation, Minisymposium on Base Points and Computer Aided Geometric Design, SIAM Conference on Geometric Design, Tempe, AZ, November 1991.

- **Real time inverse kinematics for general 6R manipulators**
  - Invited colloquium, Department of Computer Science, Stanford University, Palo Alto, CA, October 1991.

- **A New Approach for Curve and Surface Intersection**
  - Invited colloquia, Hewlett-Packard Research Laboratories, Palo Alto, CA, March 1991.

- **Efficient Algorithms for Inverse Kinematics**
  - Invited Speaker at Industrial Liasion Program, College of Engineering, University of California, Berkeley, CA, March 1991.

- **Implicitizing Rational Parametric Surfaces**
  - Invited Workshop speaker, Geometric Design Seminar, Wayne State University, Detroit, MI, May 1990.

- **Regular Curves and Proper Parameterizations**
  - Invited colloquium, Indian Institute of Technology, Delhi, January 1990.

- **Multipolynomial Resultant Algorithms**
  - Invited presentation, Minisymposium on Computational Algebraic Geometry and Geometric Modeling, SIAM conference on Geometric Design, Tempe, Arizona, November 1989.